Eight-hour Electrocardiogram: Technique and Clinical Application*

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The standard electrocardiogram is a sampling of but a small portion of the daily cardiac activity, and is only standardized for the supine position and the basal state. Such technique is not likely to reveal transient disturbances of cardiac rhythm and ST–T segment configuration. Accordingly, interest has been directed towards obtaining prolonged electrocardiographic recordings in ambulatory patients.

A small, portable, battery-operated tape recorder capable of recording for 8–10 hours has been in use for several years (Holter, 1961; Gilson, Holter, and Glasscock, 1964). The complete system consists of three separate instruments: the tape recorder itself, called the Electrocardiocorder; a rapid playback unit, called the Arrhythmiagraph-AVSEP; and a slow playback unit called the Electrocardiocharter. The Arrhythmiagraph-AVSEP has two display screens, one superimposing all complexes on the same portion of the screen in rapid succession, and the other displaying successive R–R intervals in a bar graph array. The first reveals changes in configuration and the second changes in heart rate. A further aid is an audible tone which changes in pitch when the rate or rhythm changes. The Electrocardiocharter allows reproduction of portions of the recording in standard electrocardiographic format.

In a recent clinical evaluation of this system, it was found to be most useful in evaluating obscure cerebral and cardiac symptomatology (Corday et al., 1965; Norland and Semler, 1964).

In our laboratory, we were able to avoid the expense of this entire system and indeed move it one step closer to automation, by utilizing an inexpensive oscilloscope and building a simple rapid playback system.

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We shall describe our experiences with these recordings and various forms of rapid data retrieval, and indicate areas of practical application.

TECHNIQUE

During the past 2 years in our laboratory over 300 ambulatory patients have been monitored with the Electrocardiocorder for the following reasons: evaluation of chest pain, palpitation, dizziness, syncope, known arrhythmias, control of cardioactive drug therapy, and assessment of implanted pacemaker function.

Various bipolar chest lead positions were chosen, depending on the chest configuration, and hair distribution of the subject. These positions were chosen to allow as little motion between the electrodes and the thoracic cavity as possible and were therefore usually over bony prominences. Common positions were on both sides of the chest anteriorly, between clavicle and apex of the heart, and between anterior and posterior chest.

Good recordings were obtained with the Avioni electrodes supplied with the tape recorder, as well as Beckman Silver-Silver chloride electrodes. We found it essential to clean the skin thoroughly with acetone and to fasten the electrodes with Elastoplast or non-allergenic tape.

Two separate battery chargers were needed to maintain battery strength, especially when the recorders were in frequent use. After each recording, the battery was completely charged on one charger, then maintained on a separate charger.

The recordings were displayed on a multipurpose oscilloscope (Tektronix type 561 with P–7 phosphor, type 3A3 vertical amplifier, and type 67 time base generator), allowing both superimposition and serial display of successive complexes. Each run was accomplished at a tape speed of 7½ in. (19 cm.) per second and took approximately 10 minutes. Recently some tapes have been analysed on a special oscilloscopic camera by the technique of contourography (Webb, 1965). This superimposes successive tracings of three cycle lengths, each with progressive vertical displacement.
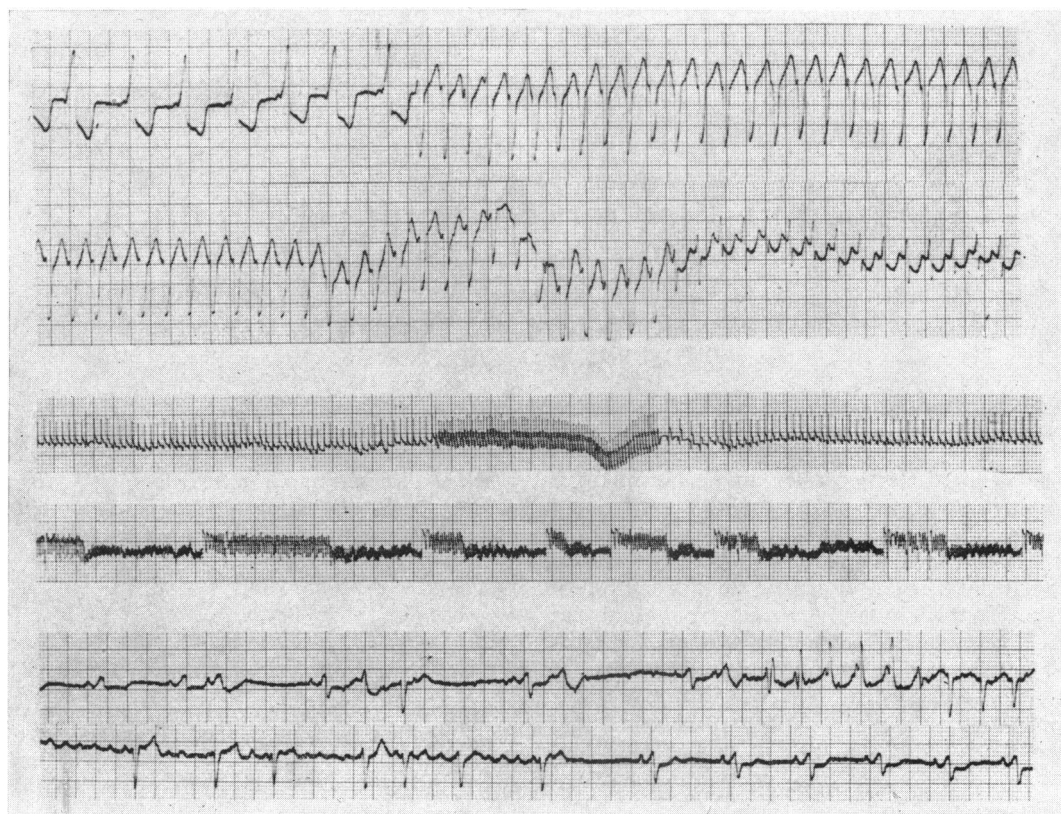
FIG. 1.—The upper two strips are continuous and show a paroxysm of tachycardia in a patient with Wolff-Parkinson-White syndrome. Note the change in configuration of the QRS complex from wide to narrow without a break in the rhythm during the paroxysm. The third strip is a compressed recording covering three minutes and including one paroxysm. The fourth strip is a compression of 30 minutes of recording showing numerous paroxysms of tachycardia (represented by the lower amplitude darker segments). The lower two strips are continuous and show a very brief paroxysm of different configuration from that in the upper strips. The termination of this paroxysm clearly shows atrial flutter waves which were not observed during other paroxysms.

CLINICAL APPLICATION

The following examples are presented to illustrate some of the uses of this technique.

(1) Tape recordings were obtained from a patient with Wolff-Parkinson-White syndrome (Fig. 1, upper two strips) whose frequent episodes of tachycardia had been resistant to courses of digitalis, dilantin, quinidine, digitalis plus atropine, prostigmine, digitalis plus quinidine, tapazol, and guanethidine. Compressed tracings (Fig. 1, middle two strips) gave information concerning the frequency of the paroxysms and enabled each one to be quickly found and reproduced in standard format. The termination of one such paroxysm (Fig. 1, lower two strips) showed flutter waves and suggested another trial of digitalis. Accordingly, she was again treated with digitalis, this time in much higher doses, and has subsequently remained free of symptoms.

(2) Figure 2 was obtained in a patient for evaluation

of her palpitation which may be seen to be due to a combined atrial and ventricular tachycardia (see legend). The frequency of these attacks is revealed by means of a Contourograph in Fig. 3.

(3) In a patient with recent onset of 'palpitation' associated with swallowing, tape recordings in conjunction with œsophageal motility studies revealed episodes of supraventricular tachycardia (Fig. 4), each initiated during the relaxation phase of the œsophagus. Further recordings revealed no response to quinidine and pronethalol but a good response to a tranquillizer.

(4) Tape recordings for evaluation of a 'persistent' nodal rhythm revealed retrograde conduction to the atria and numerous instances of reciprocal beating (Fig. 5, upper strip). This was found to revert quickly to sinus rhythm during walking (Fig. 5, lower strip) but was little affected by drugs including atropine.

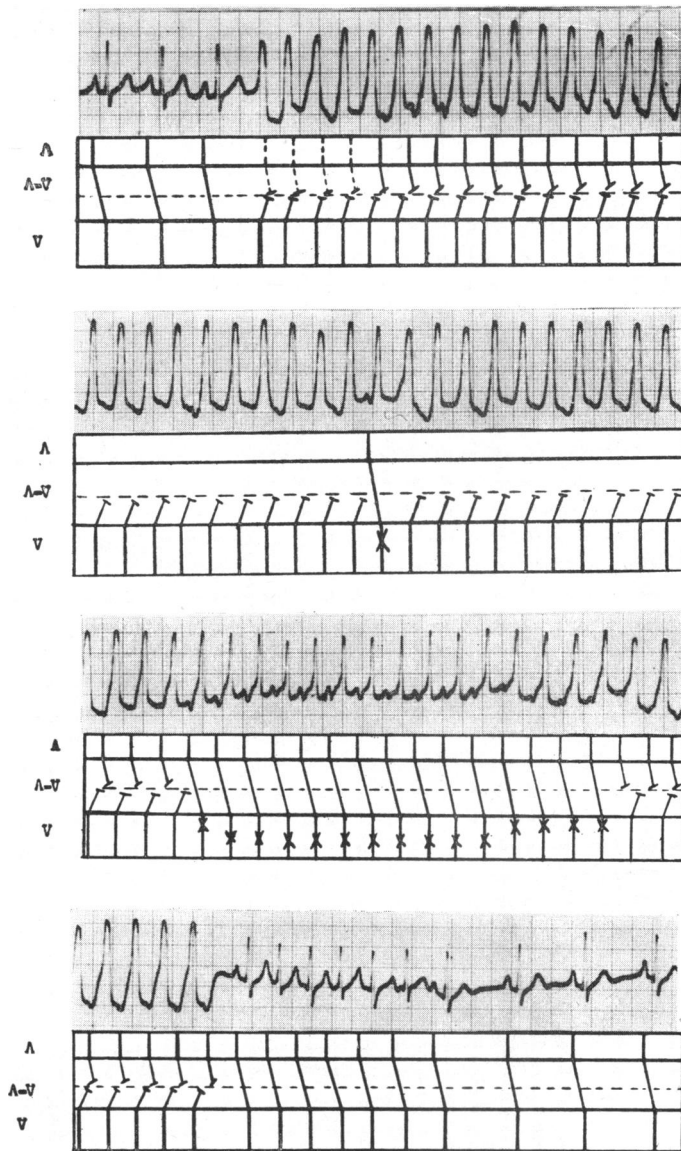(5) During evaluation of a patient whose artificial pacemaker had failed, tape recordings revealed a 2:1 AV

FIG. 2.—Continuous strips of a paroxysm of tachycardia in a 39-year-old woman complaining of palpitations. Note two types of QRS complex during the paroxysm. The widened complexes are thought to represent ventricular tachycardia and the narrow ones in the bottom strip atrial tachycardia. The single narrow complex in the second strip and the narrow complexes in the third strip are capture beats with varying degrees of fusion. The occurrence of capture beats is most unusual at this rate.

conduction when the atrial rate slowed (Fig. 6). As a result, drugs which speeded the atrial rate were avoided in his treatment.

(6) A patient with Stokes-Adams attacks whose electrocardiogram was interpreted as showing 'complete heart block' was being treated with isoprenaline and considered for pacemaker implantation. Tape recordings revealed periods of conduction when the atrial rate speeded (Fig. 7, upper and middle strips) or the nodal rate slowed. The interpretation based on the tape analysis was that the cardiac rhythm was a 'cryptic' 2:1 block according to the mechanisms described by Dressler, Roesler, and Specter (1952). As a result, isoprenaline was discontinued in favour of atropine, operation was postponed, and finally over a period of several months, 1:1 conduction was established (Fig. 7, lower strip).
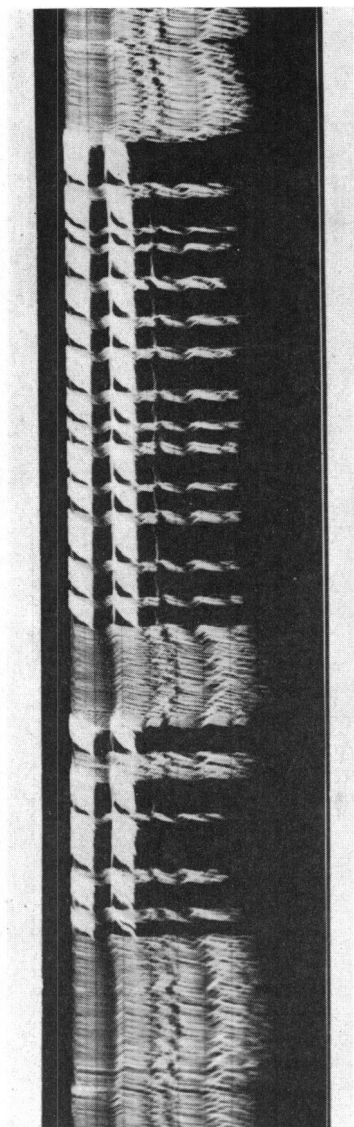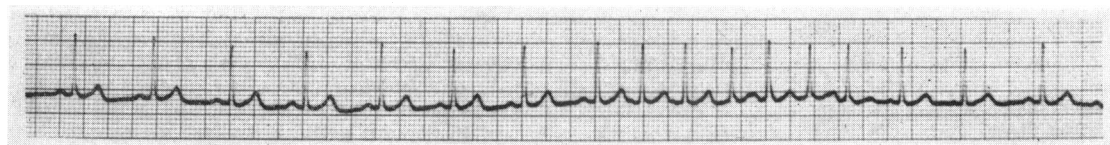
(7) During evaluation of a 19-year-old woman complaining of vague 'tightness in the chest and palpitations' but without clinical or laboratory stigmata of heart disease, tracings were obtained as shown in Fig. 8 with marked ST–T changes which could be correlated with changes in body position but not with the chest discomfort.

(8) Figure 9 illustrates successive ischæmic changes in ST–T configuration on both fast and slow playbacks during an evaluation of a patient with chest pain, who had had a previous myocardial infarction. These could be correlated with exercise and were therefore thought to be anginal attacks.

CONCLUSIONS

Continuous 8-hour tape recordings with rapid analysis have wide application in several areas of cardiac investigation. It is particularly helpful in the study of arrhythmic mechanisms where it may yield clues to proper choice and dosages of drugs for therapy, the diagnosis of obscure neurological and cardiac symptoms, and in the study of pacemaker function. In the evaluation of chest pain, ST segment deviations have to be closely correlated with the patient's activity and symptomatology for accurate interpretation to be made. This is best illustrated in examples 7 and 8 where typical 'ischæmic' changes occurred in a young girl without demonstrable heart disease and in a man with classical angina pectoris. In the 19-year-old girl these changes could be closely correlated and reproduced by standing and were not associated with chest pain, suggesting the condition of 'vaso-regulatory asthenia', as described by Friesinger et al. (1965) and Lachman, Semler, and Gustafson (1965).

Areas of investigation which seem suitable for these techniques are the study of arrythmias in the early (Mazzarella, Bruce, and Green, 1966) and late post-infarction period, during the course of renal dialysis and radiological and operative procedures, and the re-evaluation of normal and abnormal cardiovascular changes occurring in sleep, pregnancy, and daily activity (Hinkle et al., 1964).

It appears that one need not undergo the expense of the entire system described by Holter (1961) as the Arrhythmiagraph-AVSEP displays may be

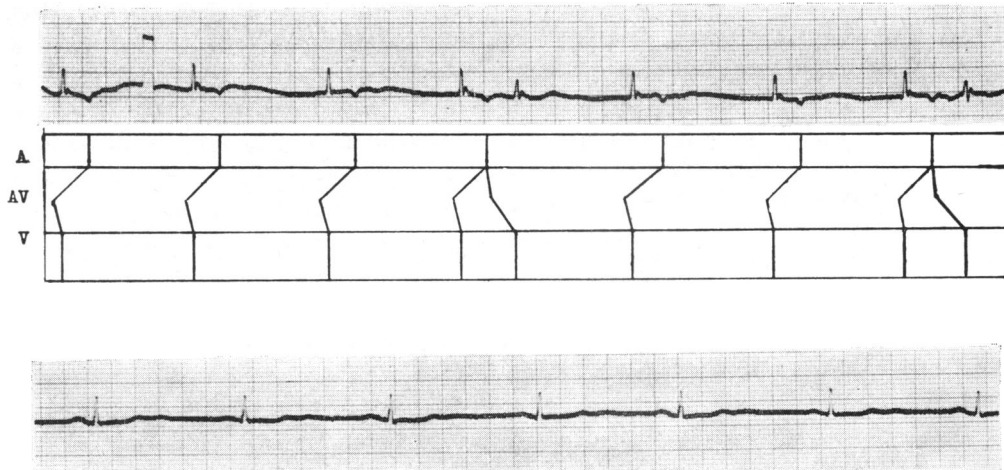FIG. 4.—A brief run of paroxysmal supraventricular tachycardia occurring during swallowing.

FIG. 5.—Upper strip and diagram show nodal rhythm with reciprocal beats (bipolar chest lead). Lower strip shows normal sinus rhythm on walking.
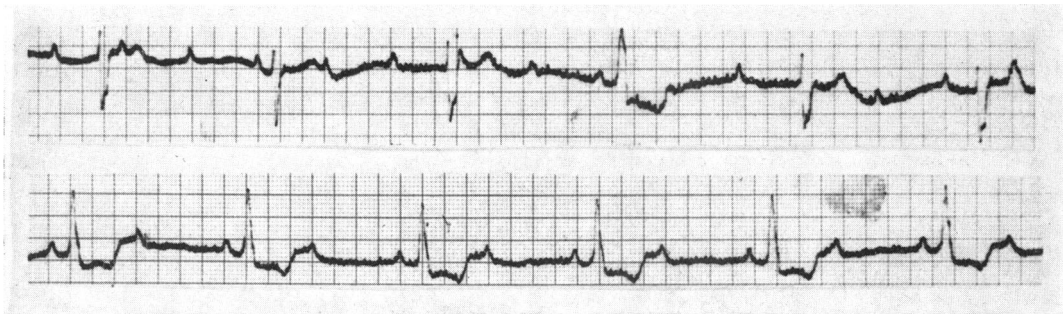

FIG. 6.—Upper strip shows high grade A–V block with a solitary capture beat (4th QRS complex). Atrial rate is 100 a minute. Lower strip shows 2:1 A–V conduction when the atrial rate slows to 75 a minute.
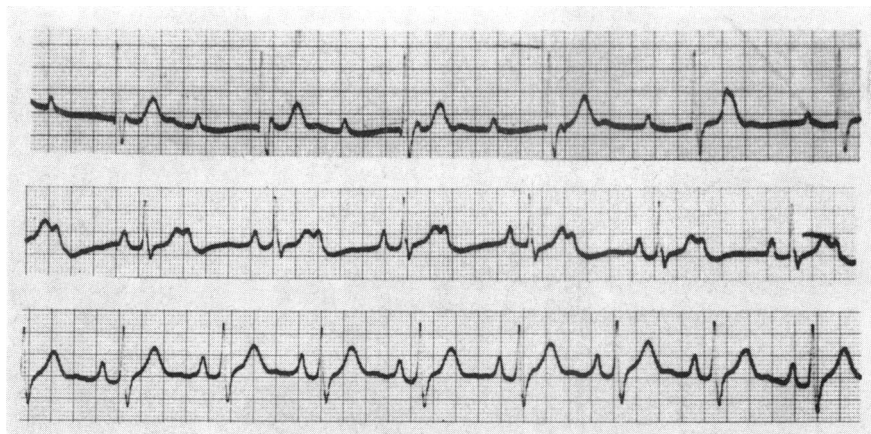

FIG. 7.—'Cryptic' 2:1 A–V block as described by Dresser *et al.* (1952). Upper two strips taken during the same eight-hour period of recording. The upper strip shows complete heart block, atrial rate 80 a minute, ventricular rate 48 a minute. An increase in the atrial rate to 104 a minute (middle strip) allows overt 2:1 A–V conduction. Lower strips taken several months later shows normal sinus rhythm.
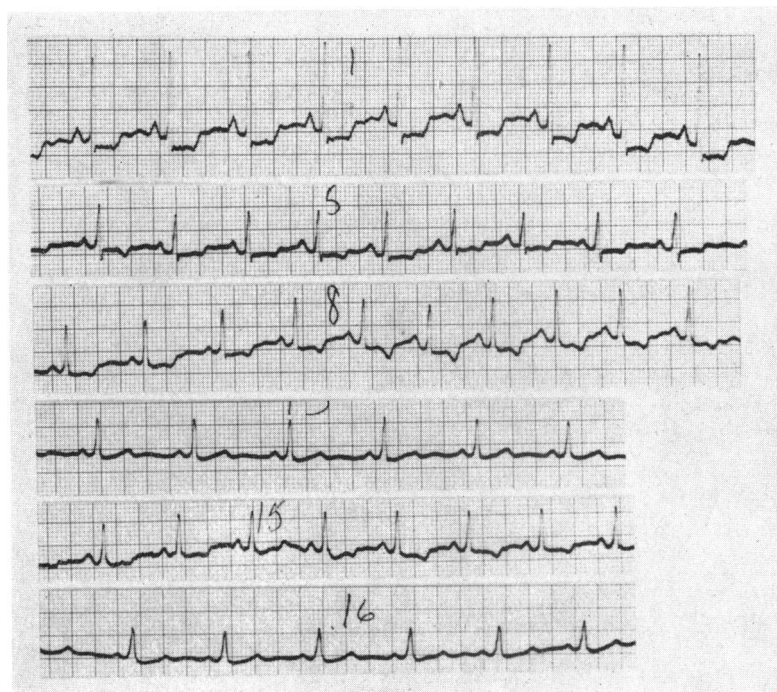
2A

FIG. 8.—Selected strips from an eight-hour recording in a 19-year-old girl. Note varying degrees of 'ischæmic' ST–T wave depressions in first, second, third, and fifth strips.
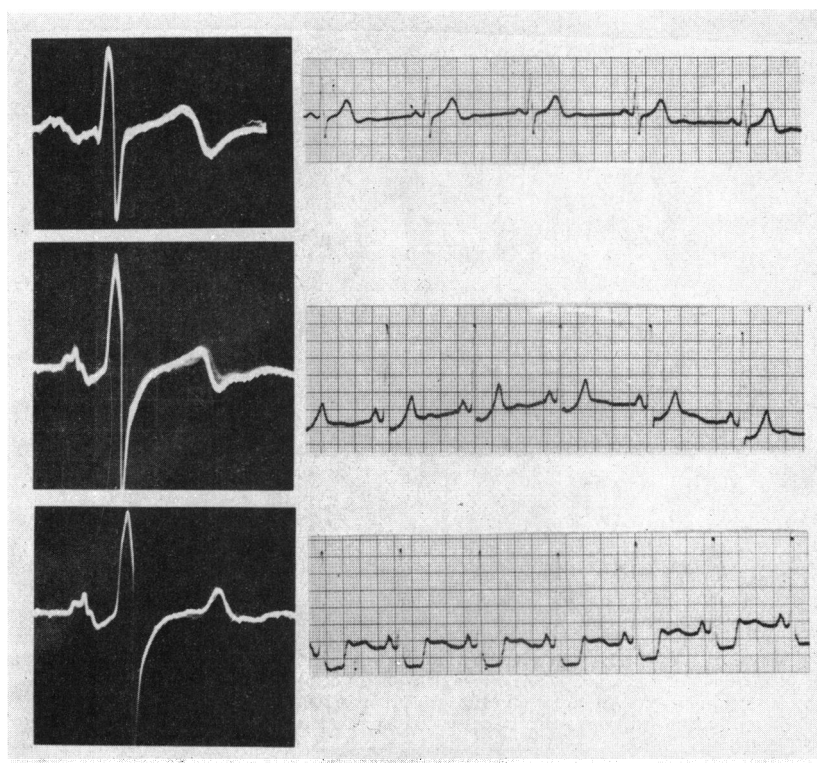

FIG. 9.—Photographs of superimposed complexes at a rapid speed are shown on the left.   The ST segment alterations correspond with those seen in the standard ECG playback on the right.   The right bottom strip shows marked ST segment depression with an episode of chest pain.   On the rapid playback (lower left) this s revealed by downward and rightward displacement of the 'J point'. The configuration of the rapid playback differs from the standard tracings because they are the first derivatives of the original signals.

simulated by ordinary oscilloscopes and inexpensive circuits. Abnormalities are easily seen in these displays. Other methods of data retrieval such as compressed tracings and the Contourograph (Webb, 1965) appear to be useful, and further work in these areas seems worth while.

SUMMARY

Analysis of 8-hour tape recorded electrocardiograms may be accomplished by relatively inexpensive equipment, yielding easily recognized abnormalities. Typical examples of the usefulness of these techniques are presented. Further areas of investigation in terms of equipment and clinical material are suggested.

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